Observations on Ants, Bees, and Wasps.—Part III. By Sir John Lubbock, Bart., F.R.S., F.L.S., M.P., D.C.L., Vice-Chancellor of the University of London.

[Read November 4, 1875.]

Ants.

In my second paper on this subject I gave some cases which show that if ants find stores of food, they do not by any means in all instances bring friends to assist in securing the treasure.

Experiments with Larvæ.

Again, Feb. 7, I put some larvæ in three porcelain cups in the feeding-box of a frame containing a nest of *Formica flava*, about 6 inches from the entrance of the frame, and put at 8 and 8.29 A.M. respectively two ants to the larvæ in the left-hand cup. They each carried off a larva and returned as follows :—

No. 1.	No. 2.		
At 8.35	....	returned	again and took another.
9. 0	....	,,	,,
	9. 7	,,	,,
	9.20	,,	,,
9.30	....	,,	,,
	9.43	,,	,,
9.54	....	,,	,,
	9.56	,,	,,
	10.20	,,	,,
10.25	....	,,	,,

At 10.43 a strange ant came to the larvæ in the right-hand cup. I imprisoned her.

At	11. 0	returned	again and took another.
11. 1	....	,,	,,
	11. 9	,,	,,
11.15	....	,,	,,
	11.20	,,	,,
	11.29	,,	,,
11.37	....	,,	,,
	11.40	,,	,,
	11.52	,,	,,

At 12.2 a stranger came to the larvæ in the left-hand cup. I imprisoned her.

No. 1.	No. 2.		
At 12. 3	.... returned again and took another.		
	12.15	„	„
	12.30	„	„
12.37	....	„	„
	12.41	„	„
	12.50	„	„
	15.58	„	„
1. 0	....	„	„
	1. 7	„	„
1.12	....	„	„
	1.16	„	„
	1.28	„	„
1.32	....	„	„
	1.35	„	„
	1.44	„	„
1.50	....	„	„
	1.55	„	„
	2. 6	„	„
2. 9	....	„	„
	2.17	„	„
	2.29	„	„
2.39	....	„	„
	2.42	„	„
2.49	2.49	„	„
3. 0	....	„	„
	3. 3	„	„

At 3.10 a stranger came to the left-hand cup. I imprisoned her.

At	3.14 returned again and took another.		
3.15	....	„	„
	3.24	„	„
3.31	....	„	„
	3.34	„	„
3.36	....	„	„

At 4.10 a stranger came to the middle cup. I imprisoned her.

At 4.45	.... returned again and took another.		
	5.50	„	„
6. 2	6. 2	„	„
	6.17	„	„

No. 1.	No. 2.		
At	6.26 returned again and took another.		
	6.46	„	„
	6.52	„	„
7. 4	....	„	„
	7. 7	„	„
	7.13	„	„
	7.18	„	„
7.48	7.48	„	„

After this they were not watched any more. It will be observed that the second ant made many more visits than the first—namely, forty-two in about eleven hours, as against twenty-six in eleven hours and a half. During this time two strangers came to the larvæ in the cup they were visiting, and three to the other two cups.

The following case is still more striking. On July 11, at 11 A.M., I put a *F. flava* to some pupæ of the same species, but from a different nest. She made eighty-six journeys, each time carrying off a pupa, with the following intervals. Commencing

at 11. 0,	At 1.33 again
11. 5 she returned.	1.43 „
11. 9 returned again.	1.49 „
11.16 again	1.52 „
11.20 „	1.56 „
11.24 „	2. 2 „
11.29 „	2.10 „
11.36 „	2.17 „
11.49 „	2.25 „
11.55 „	2.29 „
12. 0 „	2.32 „
12. 5 „	2.35 „
12.16 „	2.37 „
12.30 „	2.40 „
12.40 „	2.43 „
12.44 „	2.47 „
12.50 „	2.53 „
1. 1 „	2.56 „
1.10 „	2.59 „
1.19 „	3. 2 „
1.27 „	3. 7 „

At 3.10 again.	At 4.30 again.
3.13 „	4.33 „
3.16 „	4.40 „
3.20 „	4.43 „
3.25 „	4.45 „
3.33 „	4.49 „
3.35 „	4.53 „
3.38 „	4.55 „
3.40 „	4.58 „
3.47 „	5. 3 „
3.53 „	5. 7 „
3.57 „	5.12 „
4. 0 „	5.19 „
4. 3 „	5.22 „
4. 5 „	5.25 „
4. 8 „	5.28 „
4.12 „	5.32 „
4.15 „	5.35 „
4.18 „	5.39 „
4.20 „	5.50 „
4.23 „	7. 5 „
4.26 „	7.12 „

After which she did not come again till 8, when we left off watching. During the whole of this time she did not bring a single ant to help her. Surely it would have been in many respects desirable to do so. It will be seen that some of the pupæ remained lying about and exposed to many dangers from 11 A.M. till 7 P.M.; and when she left off working at that time, there were still a number of the pupæ unsecured; and yet, though she had taken so much pains herself, she did not bring or send others to assist her in her efforts or to complete her work.

Experiments with Pupæ.

July 11. I had put out some pupæ of *F. flava* in the central park. At 5.55 a *F. fusca* found them and carried one off.

At 6. 0	she returned and took another.	Again
6. 1	„	„
6. 3	„	„
6. 4	„	„
6. 5	„	„

At 6. 6 she returned and took another. Again

6. 7	"	"
6. 8	"	"
6. 9	"	"
6.10	"	"
6.11	"	"
6.12	"	"
6.14	"	"
6.15	"	"
6.16	"	"
6.17	"	"
6.19	"	"
6.20	"	"
6.21	"	"
6.23	"	"
6.25	"	"
6.27	"	"
6.29	"	"
6.30	"	"
6.31	"	"
6.33	"	"
6.35	"	"
6.36	"	"
6.37	"	"
6.38	"	"
6.40	"	"
6.41	"	"
6.45	"	"
6.47	"	"
6.49	"	"
6.50	"	"
6.51	"	"
6.52	"	"
6.53	"	"
6.55	"	"
6.56	"	"
6.57	"	"
7. 0	"	"
7. 1	"	"
7. 2	"	"
7. 6	"	"

After the 45 visits, she came no more till 8; but when I returned at 10 I found all the pupæ gone. During the time she was watched, however, she brought no other ant to assist.

Experiments with Larvæ.

I also made similar experiments with *Myrmica ruginodis*, imprisoning (as before) all ants that came except the marked ones.

Sept. 24. I put out two lots of larvæ; and to one of them I placed two specimens, which I will call 1 and 2. They returned as follows, carrying off a larva on each journey:—

No. 1.	No. 2.	
10.23		
	10.26	
10.28		
	10.32	
10.34		
	10.37	
10.40		
	10.41 bringing a friend.	
10.50		
	10.55	
	11. 6	
	11.16	
11.40		
	11.44	
11.45		
		11.46 a stranger came alone.
	11.56	
12. 0		
	12. 6 bringing a friend.	
12.11		
	12.15	
12.16		
		12.17 a stranger came alone.
	12.22	12.22 „ „
	12.29	
	12.34	
12.36		
	12.40	
		12.45 a stranger found the
	12.47	second lot of larvæ.
	12.53	

No. 1.	No. 2.	
		12.58 two strangers found
	12.59	the second lot of larvæ.
	1. 5	
1. 6		
		1. 7 a stranger found the
	1.16	second lot of larvæ.
1.20		
	1.21	
	1.26	
	1.35	
1.42		
	1.47	
	1.54	
1.55 with 2 friends.		
	1.59	
2. 2		
		2. 3 a stranger found the
	2. 4	larvæ.
2. 9 with a friend.		
	2.10	
2.16		
	2.18	
2.24		
	2.25	2.25 a stranger found the
	2.34	second lot of larvæ.
2.36		
	2.41	
2.44		
	2.45	
	2.50	
2.51		
	2.55	
	3. 0	
3. 1		
	3. 6	
3.10	3.10	
	3.17	
3.18		
	3.22	
	3.27	

No. 1.	No. 2.
3.28	
	3.36
3.40	
	3.47
3.48	
	3.53
3.55	
	3.59
4. 0	
	4. 7
4. 8	
	4.14
4.16	
	4.20
4.27	
	4.31
4.35	
	4.39 with a friend.
4.42	4.42
	4.47
4.53	4.53
	4.58
	5. 3
5. 5	
	5. 9
5.17	5.17
5.25	
5.32	
5.40	
5.46	
5.55	
6. 5	
	6. 8
6.11	
	6.16
6.20	

They came no more up to 7.30, when we left off watching. The following morning at 6.5 I found No. 1 wandering about, and evidently on the look-out. I put her to some larvæ; and shortly afterwards No. 2 also found them. Their visits were as follows:—

No. 1.	No. 2.	
6.10		
6.21		
6.36		
	6.42	
6.44		
6.52		
7. 1	7. 1	
	7. 8	
7.11		
	7.12	
	7.22	
	7.29	
		7.30 a strange ant
	7.35	found the larvæ.
7.40		
7.49		
	7.54	
8. 5		
8.13		
8.25		
8.31		
8.39		
8.44		
8.48		

Thus, during this period these two ants carried off respectively 62 and 67 larvæ; 10 strangers found the larvæ, half of them exactly coming to the lot visited by the ants under observation.

Again. Sept. 27, at 3.55 P.M., I put a *F. nigra* to some larvæ of *F. flava*. She returned as follows :—

4. 3	4.52
4.11	4.56
4.21	5
4.25	5. 5
4.28	5.10
4.31	5.14
4.37	5.18
4.40	5.23
4.44	5.29
4.48	5.40

5.43	5.54
5.46	5.59
5.50	

when she met with an accident. During this time no other ant came to the larvæ.

On Oct. 1, at 6.15 A.M., I put three specimens of *F. nigra* to some larvæ of *F. flava*. One did not return; the other two behaved as follows:—

No. 1 returned to the larvæ at	No. 2 at	Strangers came at
6.52		
	7.12	
		7.14 to lot 2.
	7.22	
7.30		
	7.32	
7.42	7.42	
		7.45 to lot 3.
	7.50	
7.54		
	8. 0	
8. 1		
8. 6 with a friend.	8. 6	
	8. 9	
8.10		
8.17		
		8.19 to lot 1.
		8.23 „
8.25		
	8.26	
8.32		
8.36		
		8.37 „
	8.38	
8.39		
	8.41	
8.44		
		8.45 „

Here I left off watching for half an hour.

9.22	
	9.28

No. 1 returned to the larvæ at	No. 2 at	Strangers came at
9.29		
9.35	9.35	
9.41		
	9.45	
9.47		
9.50		
	9.52	
9.54 with a friend.		
9.57		
		9.58 to lot 1.
	10. 0	
10. 1		
10. 9		
	10.11	
10.13 with a friend.		
10.16	10.16	
	10.25	
	10.30	
	10.36	
	10.46	
	10.50	
10.55		
	10.58	
11. 0		
	11. 2	
11. 3		
11. 7		
	11. 8	
	11.15	
11.16		
11.19	11.19	
11.23		
	11.25	
11.27		
	11.29 with a friend.	
		11.30
11.33		
	11.35	
11.37		
11.41		

No. 1 returned to the larvæ at	No. 2 at	Strangers came at
	11.42	
11.45		11.47 to lot 1.
	11.48	
11.49		
11.53		
	11.59	
12. 1		
12. 4		
12. 8		
	12. 9	
12.11		
		12.14 ,,
12.15	12.15	
12.18		
		12.19 ,,
	12.20	
12.21		
12.25		
	12.29 with a friend.	
12.30		
12.35		
	12.36	
12.39		
12.42		
	12.43	
12.45		
	12.47	
12.48		
12.51		
	12.53	
12.54		
		12.56 ,,
12.57	12.57	
1. 0 with friend.	1. 0	
1. 2		
1. 5		
1. 7		
	1. 9	
1.10		
		1.11 ,.

No. 1 returned to the larvæ a	No. 2 at	Strangers came at
1.13		
	1.14	
1.15		
1.18	1.18	
1.21		
1.24		
1.27		1.27
	1.28	
1.30		
1.33		
	1.35	
1.36		
1.39		
1.42	1.42	
1.45		
		1.46
1.48	1.48	
1.51		
	1.53	
1.57		
	1.59	
2. 1		
2. 4		
	2.15	
2.17		
2.21		
	2.22	
2.25		
2.29		
	2.31	
2.33		
2.37		
	2.39	
2.40		
	2.43	
2.44		
2.47		
	2.49	
2.50		
2.54		

No. 1 returned to the larvæ at	No. 2 at	Strangers came at
2.57		
3. 0		
	3.4 with a friend	
3. 6		
3. 9 with a friend.		
3.12		
3.14		
3.16	3.16	
3.20		
	3.21	
3.23		
3.26	3.26	
3.30	3.30	
3.33	3.33	
3.35	3.35	
3.37		
	3.38	
3.39		
3.41		
3.43		
	3.45	
3.46		
	3.48	
3.49		
3.54		
4. 0		
4. 3		
	4. 4	
4. 7		
4.12		
4.15		
4.20		
4.26		
4.29		
4.31		
		4.32
4.34		
4.36		
4.39		
	4.40	

No. 1 returned to the larvæ at	No. 2 at	Strangers came at
4.42		
		4.43
	4.44	
4.45		
4.49	4.49	
	4.55	
4.56		
	4.58	
4.59		
5. 2	5. 2	
	5. 6 with two friends, after	
5. 7	which she came no more.	
5.10		
5.13		
5.15		
5.18		
5.21		
5.25		
5.28		
5.31		
		5.33 to lot 2.
5.35	No. 1 returned to the larvæ at	
5.38	7.14	
5.41	7.18	
5.45	7.21	
5.51	7.24	
5.54	7.25	
6. 0	7.28	
6. 4	7.31	
6. 7	7.34	
6.14	7.38	
6.17	7.41	
6.20	7.44	
6.28	7.47	
6.31	7.51	
6.48	7.55	
6.54	7.59	
7. 0	8. 2	
7. 3	8. 5	
7. 6	8.12	
7.11	8.15	

No. 1 returned to the larvæ at	No. 1 returned to the larvæ at
8.18	8.38
8.20	8.42
8.24	8.44 stranger
8.28	8.45 came.
8.32	9.44
8.35	

We continued to watch till 10.15, but she came no more. She had, however, in the day carried off to the nest no less than 187 larvæ. She brought 5 friends with her; less than 20 other ants came to the larvæ.

October 3. I put a *F. nigra* to some larvæ of *F. flava*. She returned as follows, viz.:—

1.42	3.35
1.48	3.38
1.52	3.41
2. 0	3.49 with a friend.
2. 4	3.51
2. 8	3.54
2.12 with a stranger.	3.57
2.15	4. 1
2.19	4. 4
2.24	4. 7
2.27	4.10
2.32	4.12
2.36	4.15
2.40	4.18
2.44	4.22
2.49	4.25
2.57	4.29
3. 1	4.32
3. 4	4.35
3. 7	4.38
3.10	4.43
3.13	4.46
3.15	4.49
3.18	4.54
3.20	4.57
3.23	5. 0
3.31	5. 3

5. 6	5.22
5.10	5.26
5.14	5.29
5.18	She dropped on the floor; I picked her up; and she returned at
6.40	7. 7 with 3 friends.
6.50	7.11. She now fell into some water.
6.54	
7. 4	

Experiments with Honey.

In addition to the above experiments with larvæ, I tried the following with syrup.

April 19. I put out a little syrup on eleven slips of glass, which I placed on eleven inverted flower-pots on the lawn. At 8.35 a *F. nigra* found the honey on one of the flower-pots.

8.50 she returned to the honey, and at 9. 5 went back to the nest.

9.21	„	„	9.30	„
9.42	„	„	9.50	„
10.12	„	„	10.21	„
10.35	„	„	10.46	„
11. 9	„	„	11.20	„
11.45	„	„	11.50	„
11.57	„	„	12. 2	„
12·20	„	„	12.30	„
12.45	„	„	12.53	„
1. 8	„	„	1.18	„
1.34	„	„	1.43	„
1.57	„	„	2. 7	„
2.28	„	„	2.33	„
2.49	„	„	2.53	„
2.59	„	„	3. 2	„
3. 9	„	„	3.11	„
3.29	„	„	3.30	„
3.59	„	„	4. 8	„

After which we watched till 6 P.M.; but she did not return again to the honey. During the above time 8 ants came to the same honey, and 21 to the other ten deposits.

On July 11 I put one of my specimens of *F. nigra* to some honey at 7.10. She fed till 7.25, when she returned to the nest

At 7.32 she returned.		At 7.36 another ant		came, whom I im-	
7.47	„	7.50	„	„	[prisoned.
8. 0	„	8.11	„	„	
8.18	„				
8.36	„				
8.59	„				
9.17	„				
9.38	„				
9.53	„				
10.10	„				
10.27	„				
10.44	„				
11. 6	„				
11.16	„				
11.38	„				
12. 0	„				
12.36	„	12.45	„	„	
12.56	„				
1.21	„				
1.44	„				
2.10	„				
2.21	„				
2.29	„				
2.50	„	2.51	„	„	
3. 5	„				

After this she did not come back any more up to 8 P.M.

April 25 was a beautiful day. At 9 A.M. I put some syrup in the same way on five inverted flower-pots, and at

9.10 put an ant to one of the deposits of syrup. At
9.34 another ant came to the same syrup. This one I will call No. 2. At
9.40 No. 1 returned.
10.45 No. 2 „ At 11 one came to the same honey; this I will call No. 3.
11. 7 No. 1 „ but did not come back any more.
12.31 No. 2 „ and at 12.47 went.
1.15 No. 3 „ „ 1.25 „
1.22 No. 2 „ „ 1.48 „
1.54 No. 3 „ „ 2. 3 „
2.18 No. 2 „ „ 2.30 „

2.35 No. 3 returned, and at 2.36 went.
2.56 No. 2 „ „ 3. 1 „
3.24 No. 2 returned.
4.19 No. 2 „

After which I went on watching till 7, but none of these three returned. During the day 7 ants came to this honey, and 27 to the other four deposits. Here, therefore, it is evident that the three watched ants did not communicate, at any rate, any exact information to their friends.

June 27. I placed four inverted glasses (tumblers) on the grass, and on the top of each placed a little honey. I then, at 8 o'clock, put two ants, belonging to *F. nigra*, to the honey on one of the glasses.

At 8.25 No. 1 came back, and at 8.45 she returned to the nest, but did not come to the honey any more.

At 9.5 No. 2 came out and wandered about; I put her to the honey again; she fed and at 9.22 returned to the nest.

At 9.28 she returned to the honey, and at 9.45 went back to the nest.

10.42	„	„	10.50	„
10.58	„	„	11.10	„
11.21	„	„	11.39	„
12.45	„	„	12.59	„
1.40	„	„		

I continued to watch till 7 P.M., but neither of them returned any more.

Aug. 7. I put out four small deposits of honey (which I continually renewed) on slips of glass placed on square bricks of wood and put an ant (*F. nigra*) to one of them at 9.20. She fed an went away.

At 9.35 she returned, and fed till 9.43

10.14	„	„	10.17
10.25	„	„	10.27
10.37	„	„	10.40

This time a friend came with her.

At 10.47 she returned, and fed till 10.53

11. 0	„	„	11.14
11.35	„	„	11.40
11.52	„	„	11.55
12.13	„	„	12.16
1. 0	„	„	1. 5

At 1.15 she returned, and fed till 1.18				
1.26	„	„	1.29	
1.45	„	„	1.48	
1.58	„	„	2. 1	
2. 9	„	„	2.14	
2.20	„	„	2.21	She was dis-
2.25	„	„	2.30	[turbed.
2.37	„	„	2.40	
3. 2	„	„	3. 8	
3.16	„	„	3.20	
3.39	„	„	3.41	
3.58	„	„	4. 2	
4.13	„	„	4.20	
4.29	„	„	4.36	

At this time there was a shower of rain, so I removed the honey for half an hour.

At 5. 2 she returned, and fed till 5.10			
5.20	„	„	5.25
5.33	„	„	5.37
5.42	„	„	5.45
5.50	„	„	5.52
5.58	„	„	6. 6
6.15	„	„	6.18
6.21	„	„	6.23
6.25	„	„	6.27
6.32	„	„	6.35
6.40	„	„	6.44
6.49	„	„	6.53
7.15	„	„	7.20
7.25	„	„	7.27
7.30	„	„	7.33
7.36	„	„	7.37

During the whole of this time only three other ants came to the honey.

Aug. 13. At 11 A.M. I placed a *F. fusca* from one of my nests, which I had kept for some days without food, to some honey; she fed for some minutes, leaving at 11.6.

At 11.14 she returned, leaving at 11.20			
11.30	„	„	11.35
11.40	„	„	11.45

At 11.55	she returned,	leaving at	11.58
12. 7	,,	,,	12.11
12.18	,,	,,	12.21
12.28	,,	,,	12.31
12.38	,,	,,	12.41
12.47	,,	,,	12.51
12.56	,,	,,	12.59
1. 9	,,	,,	1.15
1.24	,,	,,	1.27
1.32	,,	,,	1.35
1.46	,,	,,	1.52
1.59	,,	,,	2. 3
2.12	,,	,,	2.15
2.26	,,	,,	2.30
2.38	,,	,,	2.43
2.55	,,	,,	3. 2
3.17	,,	,,	3.24
3.35	,,	,,	3.43
3.55	,,	,,	4. 0
4.13	,,	,,	4.17
4.35	,,	,,	4.51
5.15	,,	,,	5.26
6.29	,,	,,	6.45

I continued to watch till 8, but she came no more. During the whole time no other ant came to the honey; indeed very few left the nest at all. I kept my eye on this ant for some days, and she visited the honey every now and then, while very few others came to it.

As to Power of Communication.

With reference to the cases above recorded, in which, when ants had discovered a store of food or larvæ, others also found their way to it, I was anxious to ascertain in what manner this was effected. Some have regarded the fact as a proof of the power of communication; others, on the contrary, have denied that it indicated any such power. Ants, they said, being social animals, naturally accompany one another; moreover, seeing a companion coming home time after time with a larva, they would naturally conclude that they also would find larvæ in the same spot. It seemed to me that it would be very interesting to determine whether the ants in question were brought to the larvæ, or whether they came casually. To solve this question, I tried the following

experiments during the latter days of October. I took three tapes, each about 2 feet 6 inches long, and arranged them parallel to one another and about 6 inches apart. One end of each I attached to one of my nests (*F. nigra*), and at the other end I placed a glass. In the glass at the end of one tape I placed a considerable number (300 to 600) of larvæ. In the second I put two or three larvæ only; in the third none at all. The object of the last was to see whether many ants would come to the glasses under such circumstances by mere accident; and I may at once say that scarcely any did so. I then took two ants and placed one of them to the glass with many larvæ, the other to that with two or three. Each of them took a larva and carried it to the nest, returning for another, and so on. After each journey I put another larva in the glass with only two or three larvæ to replace that which had been removed. Now, if other ants came under the above circumstances as a mere matter of accident, or accompanying one another by chance, or if they simply saw the larvæ which were being brought and consequently concluded that they might themselves also find larvæ in the same place, then the numbers going to the two glasses ought to be approximately equal. In each case the number of journeys made by the ants would be nearly the same; consequently, if it was a matter of scent, the two glasses would be in the same position. It would be impossible for an ant, seeing another in the act of bringing a larva, to judge for itself whether there were few or many larvæ left behind. On the other hand, if the strangers were brought, then it would be curious to see whether more were brought to the glass with many larvæ, than to that which only contained two or three. I should also mention that every stranger was imprisoned until the end of the experiment. The results were as follows:—

Exp. 1.—Time occupied, 1 hour. The ant with few larvæ made 6 visits and brought no friends. The one with many larvæ made 7, and brought 11 friends.

Exp. 2.—Time occupied, 2 hours. The ant with few larvæ made 13 journeys, and brought 8 friends. The one with many larvæ did not come back.

Exp. 3.—Time occupied, 3 hours. The ant with few larvæ made 24 journeys, and brought 5 friends. The one with many larvæ made 38 journeys, and brought 22 friends.

Exp. 4.—Time occupied, $2\frac{1}{2}$ hours. The ant with few larvæ did

not come back. The one with many made 32 journeys, and brought 19 friends.

Exp. 5.—Time occupied, 1 hour. The ant with few larvæ made 10 journeys, and brought 3 friends. The other made 5 journeys and brought 16 friends.

Exp. 6.—Time occupied, 1½ hour. The ant with few larvæ made 15 journeys, but brought no friends. The other made 11 journeys and brought 21 friends.

Exp. 7.—I now the reversed the glasses. Time occupied 3 hours. The ant with few larvæ made 23 journeys and brought 4 friends.

Exp. 8.—Time occupied, 1½ hour. The ant with few larvæ made 7 journeys and brought 3 friends. The one with many larvæ made 19 journeys and brought 6 friends.

Exp. 9.—Time occupied, 1 hour. The ant with few larvæ made 11 journeys and brought 1 friend. The one with many larvæ made 15 journeys and brought 13 friends.

Exp. 10.—I now reversed the glasses, the same two ants being under observation; but the ant which in the previous observation had few larvæ, now consequently had many, and *vice versâ*. Time occupied 2 hours. The ant with few larvæ made 21 journeys and brought 1 friend. The one with many larvæ made 32 journeys and brought 20 friends. These two experiments are, I think, very striking.

Exp. 11.—Time occupied, 5 hours. The ant with few larvæ made 19 journeys and brought 1 friend. The one with many larvæ made 26 journeys and brought 10 friends.

Exp. 12.—Time occupied, 3 hours. The ant with few larvæ made 20 journeys and brought 4 friends. The one with many larvæ brought no friends and made 17 journeys.

Exp. 13.—Time occupied, 1 hour. The ant with few larvæ made 5 journeys and brought no friends. The one with many made 10 journeys and brought 16 friends.

Exp. 14.—I now reversed the glasses. Time occupied, 2½ hours The ant with few larvæ made 10 journeys and brought 2 friends. The other made 41 journeys and brought 3 friends.

Exp. 15.—Time occupied, 4½ hours. The ant with few larvæ made 40 journeys and brought 10 friends. Of these, 8 came at the beginning of the experiment, and I much doubt whether they were brought; during the last hour and a half she only brought 1 friend. However, I think it fair to record the observation.

The ant with many larvæ made 47 journeys and brought 1 friend.

Exp. 16.—Time, 4½ hours. The ant with few larvæ made 20 journeys and brought 1 friend. She did not return after the first 2 hours. The other ant made 53 journeys and only brought 2 friends. This latter was the same one as in the previous experiment, when, however, she had the glass with only two or three larvæ.

Exp. 17.—Time, 1 hour. The ant with few larvæ made 6 journeys and brought no friend. The one with many larvæ made 11 journeys and brought 12 friends.

Exp. 18.—Time, 1½ hour. The ant with few larvæ made 25 journeys and brought four friends. The one with many larvæ made 20 journeys and brought 15 friends.

Exp. 19.—Time, 4½ hours. The ant with few larvæ made 74 journeys and brought no less than 27 friends. This is quite in opposition to the other observations; and I cannot account for it. She was the ant who brought 15 friends in the previous experiment, and it certainly looks as if some ants were more influential than others. The ant with many larvæ made 71 journeys and only brought 7 friends.

Exp. 20.—Time, 2 hours. The ant with few larvæ made 35 journeys and brought 4 friends. The one with many larvæ made 34 journeys and brought 3 friends.

Exp. 21.—I now transposed the two glasses. Time, 1½ hour. The ant with few larvæ made 15 journeys and brought no friends. The other made 35 journeys and brought 21 friends.

Exp. 22.—I now transposed the glasses again. Time, 2 hours. The ant with many larvæ made 37 journeys and brought 9 friends. The ant with few larvæ made 18 journeys and brought no friend. This, I think, is a very striking case. She was under observation 5½ hours; and the scene of her labour was the same throughout. The first 2 hours she had few larvæ and brought 4 friends; then for 1½ she had many larvæ and brought 21 friends; then again for 2 hours she had few larvæ and brought no friend.

Exp. 23.—Time, 1½ hour. The ant with few larvæ made 25 journeys and brought 3 friends. The other made only 9 journeys, but brought 10 friends.

Exp. 24.—I now transposed the glasses. Time occupied, 2 hours. The ant which now had few larvæ made 14 journeys, but brought no friends. The other made 37 journeys and brought 5 friends.

Exp. 25.—Time 3 hours. I put an ant for an hour to a full glass; she made 10 journeys and brought 4 friends. I then left only two or three larvæ: in the second hour she made 7 journeys and brought no friend. I then again filled the glass; and during the third hour she made 14 journeys and brought 3 friends.

The results of the above experiments are shown at a glance in the following Table.

Tabular View of Experiments on Power of Communication.

Ants.	Glass with many larvæ.			Glass with one or two larvæ.		
	Time observed.	Number of journeys.	Number of strangers.	Time observed.	Number of journeys.	Number of strangers.
	hours.			hours.		
1.	1	7	11			
2.	...	...	...	1	6	0
3.	...	...	...	2	13	8
4.	...	...	...	3	24	5
5.	3	38	22	1	10	3
6.	2½	32	19			
7.	1	5	16			
8.	1½	11	21	3	23	2
9.	...	...	...	1½	7	3
10.	1	15	13	2	21	1
11.	2	32	20	1	11	1
12.	5	26	10			
13.	...	...	...	5	19	1
14.	...	...	...	3	20	4
15.	2½	41	3	2	5	0
16.	1	10	16	2½	10	2
17.	4½	53	2	4½	40	10
18.	...	...	...	2	20	1
19.	1	11	12			
20.	...	...	...	1	6	0
21.	1½	20	15	4½	74	27
22.	...	...	...	1½	25	4
23.	4½	71	7			
24.	...	...	...	2	35	4
25.	2	34	3			
26.	1½	35	21	2	18	0
27.	2	37	9	1½	15	0
28.	1½	9	10	2	14	0
29.	2	37	5	1½	25	3
30.	1½	9	10	2	14	0
31.	2	37	5	1½	25	3
32.	2	24	7	1	7	0

It must be admitted that this mode of observing is calculated to increase the number of friends brought by the ants to the glass with only 2 or 3 larvæ, for several reasons, but especially because

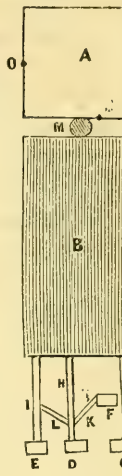
in many cases an ant which had for some time had access to a glass with many larvæ was suddenly deprived of it, and it might well be that some time elapsed before the change was discovered. Some stray ants would, no doubt, in any case have found the larvæ; and we ought probably to allow for at least 25 under this head. Again, some would, no doubt, casually accompany their friends: if we allow 25 also in this respect, we must deduct 50 from each side, and we shall have 205 against 37. Nevertheless even without any allowances, the results seem to me very definite. Some of the individual cases, especially perhaps experiments 9 10, 20, 21, and 22, are very striking; and, taken as a whole, during 47½ hours, the ants which had access to a glass containing numerous larvæ brought 257 friends; while during 53 hours those which were visiting a glass with only 2 or 3 larvæ brought only 82 to their assistance.

One case of apparent communication struck me very much. I had had an ant (*F. nigra*) under observation one day, during which she was occupied in carrying off larvæ to her nest. At night I imprisoned her in a small bottle; in the morning I let her out at 6.15, when she immediately resumed her occupation. Having to go to London, I imprisoned her again at 9 o'clock. When I returned at 4.40, I put her again to the larvæ. She examined them carefully, but went home without taking one. At this time no other ants were out of the nest. In less than a minute she came out again with 8 friends, and the little troop made straight for the heap of larvæ. When they had gone two thirds of the way, I again imprisoned the marked ants; the others hesitated a few moments, and then, with curious quickness, returned home. At 5.15 I put her again to the larvæ. She again went home *without a larva*, but, after only a few seconds' stay in the nest, came out with no less than 13 friends. They all went towards the larvæ; but when they got about two thirds of the way, although the marked ant had on the previous day passed over the ground about 150 times, and though she had just gone straight from the larvæ to the nest, she seemed to have forgotten her way and wandered; and after she had wandered about for half an hour, I put her to the larvæ. Now in this case the 21 ants must have been brought out by my marked one; for they came exactly with her, and there were no other ants out. Moreover it would seem that they must have been told, because (which is very curious in itself) she did not in either case bring a larva, and consequently it cannot

have been the mere sight of a larva which had induced them to follow her.

It remained to ascertain whether the ants which came by themselves to the larvæ found them by scent, or whether the road had been described to them; for it is obvious that the latter would imply a higher intelligence than the former. In many of the above cases ants came by themselves almost straight to the larvæ which were being visited by my marked ants, while other larvæ close by remained entirely unvisited. The stranger ants must therefore either have had the way described to them, or, having been told of the existence of larvæ, have tracked the marked ant by scent, and so found their way to the larvæ. To determine which, I made the following experiment.

Fig. 1.



In the above figure A is the ants' nest, *o* the door of the nest. M is the section of a pole on which the whole apparatus is supported. B is a board 2 feet long; C, D, E, and F are slips of glass connected with the board B by narrow strips of paper G, H, I. K is a moveable strip of paper, $1\frac{1}{2}$ inch long, connecting the glass F with the strip H; and L is another moveable strip of paper, as nearly as possible similar, connecting H and I. On each of the slips of glass C and F I put several hundred larvæ of *F. flava*. The object of the larvæ on C was to ascertain whether, under such circumstances, other ants would find the larvæ accidentally; and I may say at once that none did so. I then put the ant (A), whom I had imprisoned over night, to the larvæ on F. She took one, and, knowing her way, went straight home over the bridge K and down the strip H. Now it is obvious that by always causing the marked ant (A) to cross the bridge K on a particular piece of paper, and if at other times the papers K and L were reversed, I should be able to ascertain whether other ants who came to the larvæ had had the direction and position explained to them, or whether, having been informed by A of the existence of the larvæ, they found their way to them by tracking A's footsteps. If the former, they would in any case pass over the bridge K by whichever strip of paper it was constituted. On the other hand, if they found the larvæ by tracking, then as the piece of paper by which A passed was transferred to L, it would mislead them and carry them away from the larvæ to I. In every case,

then, I transposed the two papers forming the little bridges K and L as soon as the ant A had crossed over.

I put her to the larvæ on F at 6.15 A.M. After examining them carefully, she returned to the nest at 6.34. No other ants went out; but she at once reappeared with 4 friends and reached the larvæ at 6.38. None of her friends, however, crossed the bridge; they went on to D, wandered about, and returned home. A returned to the larvæ at 6.47, this time with one friend, who also went on to D and returned without finding the larvæ.

7. 0. Ant A to larvæ.

7. 8	„	An ant at	7.10	went over	L to I.
7.17	„	with a friend, who at	7.21	„	„
7.25	„	with two friends, one of whom at	7.27	„	„
7.32	„	the other at	7.35	„	„
7.39	„	with a friend who went on to D, and then at	7.41	„	„
7.46	„	An ant at	7.42	„	„
7.55	„	„	7.47	„	„
8. 3	„	„	7.48	„	„
8. 8	„	„	7.54	„	„
8.19	„	„	7.57	„	„
8.24	„	„	9.10	found	the larvæ.
8.39	„	„	9.30	went over	L to I.
8.50	„				
9.12	„				
9.22	„				
9.40	„				
9.47	„				
9.55	„				
10.35	„				

At 10.35 I imprisoned her till 12.30, when I put her again to the larvæ.

12.48 back to larvæ.

12.55	„	An ant at	12.58	went over	L to I.
1. 0	„	„	1. 1	„	„
1.15	„	„	1.10	„	„
1.20	„	„	1.13	„	„

After this she did not come any more. During the time she

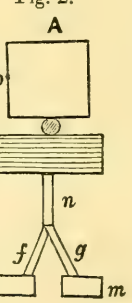
made, therefore, 25 visits to the larvæ; 21 other ants came a distance of nearly 4 feet from the nest and up to the point of junction within 2 inches of the larvæ; but only 1 passed over the little bridge K, while 15 went over the bridge L to I. On repeating this experiment with another marked ant, she herself made 40 journeys, during which 19 other ants found their way to the point of junction. Only 2 went over the little bridge to the larvæ, 8 went over L to I, and the remainder on to D.

Another made 16 journeys; and during the same time 13 other ants came to the point of junction. Of these 13, 6 went on to D, 7 crossed over L to I, and not one found the larvæ. Thus altogether, out of 53 ants, 20 went on to D, 30 crossed over in the wrong direction to I, and only 3 found their way to the larvæ.

From Jan. 2 to Jan. 24 (1875) I made a series of similar observations; and during this time 39 strangers came in all. Of these, 10 went straight on to D, 21 across to the paper to I, and only 8 to the larvæ.

This, I think, gives strong reason to conclude that, under such circumstances, ants track one another by scent.

Fig. 2.



I then slightly altered the arrangement of the papers as shown in the accompanying diagram (fig. 2). A, as before, is the nest, *o* being the door. B is the board; *h* is a glass on which are placed the larvæ; *m* is a similar glass, but empty; *n* a strip of paper: to the end of *n* are pinned two other strips *f* and *g* in such a manner that they can be freely turned round, so that they can be turned at will either to *h* or *m*. Under ordinary circumstances the paper *f*, as in the figure, was turned to the larvæ; but whenever a strange ant came, I turned the papers, so that *f* led to *m* and *g* to *h*. The result was so striking that I give the observation in full.

Jan. 24. I put an ant, which already knew her way, on the larvæ at 3.22.

At 3.30 she returned.					
4.15	„	At 3.38 a stranger came; and the			
4.25	„	bridge *f* being there,			
4.34	„	she went over it to *m*.			
4.42	„	3.50	„	„	
4.50	„	4.35	„	„	
4.56	„	5.15	„	„	

At 5. 5 she returned.
5.14 „
5.25 „

Jan. 25, 6.30 A.M. Put two ants, which knew their way, to the larvæ.

No. 1.	No. 2.	
Returned at 6.55.		
„ 7. 7		
	Returned at 7.11.	
„ 7.15		
	„ 7.27	
„ 7.35		
„ 7.46		
	„ 7.47	
„ 7.49		
	„ 7.51	
„ 7.53		
	„ 7.57	
„ 8. 0		
„ 8. 3		
„ 8. 8		
		8.16 stranger to *m*.
„ 8.17		
	„ 8.18	
„ 8.21		
		8.22 „
„ 8.25	„ 8.25	
		8.27 „
„ 8.29		
	„ 8.30	
„ 8.31		
	„ 8.34	
„ 8.35		
	„ 8.36	
„ 8.40	„ 8.40	
„ 8.44		
		8.45 „
	„ 8.46	
„ 8.47		
„ 8.51	„ 8.51	

No. 1.	No. 2.	
Returned at 8.55		
	Returned at 8.59	
„ 9. 3		
„ 9. 8		
„ 9.18		
„ 9.24		
„ 9.27		
„ 9.30		
„ 9.32		
„ 9.34		
	„ 9.35	
„ 9.37		
„ 9.43	„ 9.43	
		9.44 stranger to *m*.
„ 9.45	„ 9.45	
„ 9.47		
„ 9.50		
	„ 9.51	
„ 9.55	„ 9.55	
„ 9.58	„ 9.58	
„ 10. 1	„ 10. 1	
„ 10. 7	„ 10. 7	
„ 10.10	„ 10.10	
		10.11 „
	„ 10.15	
„ 10.16		
	„ 10.17	
„ 10.18		
„ 10.20	„ 10.20	
„ 10.22	„ 10.22	
„ 10.24		
„ 10.28		
	„ 10.30	
„ 10.32		
	„ 10.33	
„ 10.35	„ 10.35	
„ 10.38		
	„ 10.39	
„ 10.42	„ 10.42	
„ 10.45		

No. 1.	No. 2.		
	Returned at 10.46		
Returned at 10.48			
	„ 10.49		
„ 10.51	„ 10.51		
„ 10.53	„ 10.53		
„ 10.55			
„ 10.58	„ 10.58		
„ 11. 0			
	„ 11. 1		
„ 11. 2			
„ 11. 5			
„ 11.10			
„ 11.12			
		11.15 stranger to *m*.	
„ 11.16			
„ 11.21			
„ 11.23			
	„ 11.24		
„ 11.26	„ 11.26		
„ 11.30	„ 11.30		
„ 11.35	„ 11.35		
„ 11.36			
„ 11.40	„ 11.40	11.40	„
		11.42	„
	„ 11.43		
„ 11.45	„ 11.45		
„ 11.46			
	„ 11.50		
	„ 11.51		
	„ 11.56		
„ 11.58			
	„ 11.59		
„ 12. 0			
„ 12. 2	„ 12. 2		
„ 12. 6	„ 12. 6		
„ 12.10	„ 12.10		
„ 12.14			
„ 12.16			
„ 12.20	„ 12.20	12.20	„
„ 12.24	„ 12.30 dropped.		
	1. 2 imprisoned her.		

Returned at 12.31 — 12.35 stranger to *m*.
„ 12.36
„ 12.44
„ 12.46
„ 12.50
„ 12.54
„ 12.59
„ 1. 1

I then put her into a small bottle.

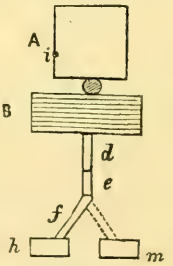
I let them out again at 7.10 on the 27th. Though the interval was so long, they began at once to work; but one unfortunately met with an accident. The other returned as follows, viz. at

7.20
7.30
7.40
7.48 stranger to *m*.
7.46
7.51
7.55
7.59

In these experiments, therefore, 17 strangers came; but at the point *n* they all took the wrong turn, and not one reached the larvæ.

Although the observations above recorded seem to me almost conclusive, still I varied the experiments once more (see fig. 3), making the connexion between the board B and the glass containing the larvæ by three separate, but similar strips of paper, *d*, *e*, and *f*, as shown in the figure. Whenever, however, a strange ant came, I took up the strip *f* and rubbed my finger over it two or three times so as to remove any scent, and then replaced it. As soon as the stranger had reached the paper *e*, I took up the strip *d*, and placed it so as to connect *e* with the empty glass *m*. Thus I escaped the necessity of changing the paper *f*, and yet had a scented bridge between *e* and *m*. The results were as follows:—

Fig. 3.



Jan. 27. At 5.30 I let out the same two ants as were under observation in the preceding experiments.

	No. 1.			No. 2.	
Returned at	5.40, the other not till			6.49	
„	6. 0				
„	6. 8				
„	6.26				6.22 stranger to *m*.
„	6.32				
„	6.37				
„	6.41				
„	6.45				
„	6.48	„	„	6.49	6.50 „
„	6.51				6.52 „
„	6.54	„	„	7. 0	6.53 stranger to larvæ.
„	7. 1				
„	7. 5	„	„	7. 6	
„	7. 9	„	„	7.12	
„	7.17	„	„	7.17	
		„	„	7.22	7.27 stranger to *m*.
„	7.25	„	„	7.28	
„	7.29	„	„	7.34	

I then put them into the bottle.

Jan. 28. Let them out at 6.45.

	No. 1.	No. 2.	
Back at	7. 0		
„	....	7. 3	
„	7. 5		
„	7.11		
„	....	7.12	
„	7.16		
„	7.21		
„	7.27		
			7.31 stranger to *m*.
„	....	7.32	
„	....	7.42	
„	7.45	She dropped into	
„	7.52	some water.	
„	8. 2		
„	8.11		
„	8.20		
„	8.26		
„	8.30		
„	8.36		

No. 1.

Back at 8.40
„ 8.44
„ 8.48

I then put them into the bottle.

Jan. 29. I let them out at 7.35 A.M.

No. 1 returned at 7.47, after which I saw her no more. I fear she must have met with an accident.

No. 2 returned at
7.56
8. 8
8.18
8.28
8.35
8.42
8.48
8.50 a stranger came to the larvæ, marked her No. 3.
8.56
9. 5
9.19 No. 3
9.20
9.26
9.36
9.46 2 strangers to larvæ.
9.47 5 strangers to *m*.

At 9.40 I found one of the ants which had been under observation on the 24th, and put her to the larvæ. She returned as follows (No. 4).

No. 4.
9.50
9.52
9.55
9.58
10. 3
10.10
10.12
10.15
10.20 10.20
10.23
10.26 10.26
10.29
10.33
10.36
10.37
10.40
10.41 10.41

No. 2.	No. 3.	No. 4.	
10.44		10.44	
10.48			
		10.51	
10.53			
	10.56		
		10.57	
10.59	10.59		
	11. 2	11. 2	
11. 4			
			11. 5 stranger to larvæ.
	11. 7		
			11. 8 „ „
11. 9	11. 9		
		11.10	
	11.13		
		11.14	
	11.16		
11.17			
		11.18	
	11.20		11.20 „ „
			11.21 „ „
			11.22 stranger to *m*.
11.23	11.23	11.23	
			11.25 stranger to larvæ.
	11.26		
11.28			
	11.30		
11.33	11.33		
			11.35 „ „
11.40			
	11.42		
		11.44	
	11.46		
11.47			
	11.50	11.50	
	11.54	11.54	
			11.55 stranger to *m*.
	11.58	11.58	
12. 0			
	12. 1		
			12. 6 „ „
		12. 7	
	12. 8		
12.10			
	12.13		
		12.14	

No. 2.	No. 3.	No. 4.
12.15		
	12.18	
		12.24
	12.25	
12.27		
	12.30	
12.36	12.36	
		12.39
	12.40	
	12.43	
		12.45
	12.47	
	12.50	
		12.52
	12.53	
	12.56	
		12.57
	12.59	
		1. 0
	1. 7	1. 7
	1.12	
1.13		
		1.18
1.22		
		1.25
		1.33
		1.41
1.44		
		1.51
	1.55	
		1.56
		2. 9
		2.35

I then put her into a small bottle. We kept a look-out for Nos. 2 and 3 till 7.30 P.M.; but they did not return.

Jan. 30. Let No. 4 out at 7 A.M. She returned at 7.45.

No. 3 came of herself at	8. 0	No. 4.
Returning at	8. 9	8. 9
		8.15 stranger to larvæ.
„	8.20	
		8.25
„	8.30	
„	8.36	

	No. 3.	No. 4.	
Returning at	8.40		
		8.43	
		8.51	Stranger to *m*.
„	8.52		
		9. 3	
„	9. 5		
	Imprisoned them.		
Let them out at 10.55.			
Returning at	11. 1		
		11. 3	
		11. 8	
„	11. 9		
		11.14	Stranger to *m*.

And they went on coming regularly till 1, when I put them again in a bottle.

Jan. 31. Let them out at 6.35 A.M.

No. 3.	No. 4.	
6.55		
7.12		
	7.15	
7.21		
	7.29	
7.37		
7.42	7.42	
7.48		
	7.53	
		7.55 stranger to *m*.
		8. 0 „
8. 1		
8.12		
	8.18	
8.20		
		8.24 „
8.27		
	8.28	
8.32		
		8.36 stranger to larvæ.
8.39		
.44		

I imprisoned them.

Jan 31. Let them out at 5.35 P.M.

No. 3.	No. 4.		
	5.47		
6.25			
6.35			
6.48			
6.53			
7. 2			
7. 7			
7.11			
7.16			
7.20			
	7.23	stranger to	larvæ.
7.25			
	7.26	„	„
	7.27	„	*m.*
	7.29	„	„
7.30	7.30	„	larvæ.
Imprisoned her	7.31	„	*m.*

Feb. 1. Let her out at 7.5.

	No. 3.		
She returned at	7.20		
„	7.30		
	7.38	stranger to	*m.*
„	7.40		
„	7.48		
„	7.58		
	7.59	„	
„	8. 6		
„	8.12		
	8.14	„	
	8.17	„	
„	8.22		

Imprisoned her and let her out again at 6.20 P.M.

She returned at	6.35	
„	6.52	
„	7. 0	
„	7. 5	
„	7.15	

No. 3.

She returned at 7.20
„ 7.25
Imprisoned her.

Feb. 2. Let her out at 6.30 A.M.

She returned at 6.50
„ 7. 0
7. 2 stranger to *m*.
„ 7. 7
7.10 two strangers to *m*.
„ 7.13
„ 7.17
7.27 stranger to larvæ.
„ 7.28
„ 7.36
7.38 „ *m*.
„ 7.45
„ 7.50
7.51 „ „
„ 7.55
„ 8. 4
8. 6 „ „
„ 8.11
„ 8.18
„ 8.25
„ 8.30
„ 8.35
„ 8.45
„ 8.46
Imprisoned her.

In this experiment, then, the bridge over which the marked ant passed to the larvæ was left in its place, the scent, however, being removed or obscured by the friction of my finger; on the other hand, the bridge had retained the scent, but was so placed as to lead away from the larvæ; and it will be seen that, under these circumstances, out of 41 ants which found their way towards the larvæ as far as *e*, 14 only passed over the bridge *f* to the larvæ, while 27 went over the bridge *d* to the empty glass *m*.

Taking these observations as a whole, 150 ants came to the point *e*, of which 21 only went on to the larvæ, while 95 went

away to the empty glass. These experiments, therefore, are in entire accordance with those already laid before the Society, and seem to me to show that when an ant has discovered a store of food and others gradually flock to it, they are guided, in some cases by sight, while in others they track one another by scent.

As to their Intelligence and Provident Habits.

It is generally stated that our northern ants do not store up food. But it must be remembered that their nourishment is, for the most part, of a very perishable character, and could not be preserved. Those ants, however, which collect *Aphides* may fairly be said, in doing so, to provide for themseleves the means of subsistence.

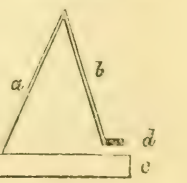
M. Lund tells the following story as bearing on the intelligence of ants*:—

"Passant un jour près d'un arbre presque isolé, je fus surpris d'entendre, par un temps calme, des feuilles qui tombaient comme de la pluie. Ce qui augmenta mon étonnement, c'est que les feuilles détachées avaient leur couleur naturelle, et que l'arbre semblait jouir de toute sa vigueur. Je m'approchai pour trouver l'explication de ce phénomène, et je vis qu'à peu près sur chaque pétiole était postée une fourmi qui travaillait de toute sa force; le pétiole était bientôt coupé et la feuille tombait par terre. Une autre scène se passait au pied de l'arbre : la terre était couverte de fourmis occupées à découper les feuilles à mesure qu'elles tombaient, et les morceaux étaient sur le champ transportés dans le nid. En moins d'une heure le grand œuvre s'accomplit sous mes yeux, et l'arbre resta entièrement dépouillé."

With reference to this interesting account, I tried the following experiment:—

Oct. 15, noon. (See fig. 4.) At a distance of 10 inches from the door of a nest of *F. nigra* I fixed an upright ash wand 3 feet 6 inches high (*a*), and from the top of it I suspended a second, rather shorter wand (*b*). To the lower end of this second wand, which hung just over the entrance to the nest (*c*), I fastened a flat glass cell (*d*) in which I placed a number of larvæ of *F. flava*, and to them I put three or four specimens of *F. nigra*. The drop from the glass cell to the upper part of the frame was only

Fig. 4.



* Ann. des Sci. Nat. 1831, p. 112.

$\frac{1}{2}$ an inch; still, though the ants reached over and showed a great anxiety to take this short cut home, they none of them faced the leap, but all went round by the sticks, a distance of nearly 7 feet. At 6 P.M, there were over 550 larvæ in the glass cell, and I reduced its distance from the upper surface of the nest to about $\frac{2}{5}$ of an inch, so that the ants could even touch the glass with their antennæ, but could not reach up nor step down. Still, though the drop was so small, they all went round. At 11 P.M. the greater number of the larvæ had been carried off; so I put a fresh lot in the cell. The ants were busily at work. At 3 A.M. I visited them again. They were still carrying off the larvæ, and all going round. At 6 A.M. the larvæ were all removed. I put a fresh lot, and up to 9 A.M. they went on as before.

The following day (Oct. 17), I took two longer sticks, each 6 feet 6 inches in length, and arranged them in a similar manner, only horizontally instead of vertically. I also placed fine earth under the glass supporting the larvæ. At 8 o'clock I placed an ant on the larvæ; she took one, and I then coaxed her home along the sticks. She deposited her larva and immediately came out again, not, however, going along the stick, but under the larvæ, vainly reaching up and endeavouring to reach the glass. At 8.30 I put her on the larvæ again, and as she evidently did not know her way home, but kept stretching herself down and trying to reach the earth under the glass cell, I again coaxed her home along the sticks. At 9.3 she came out again, and again went under the larvæ and wandered about there. At 10 I put her on the larvæ and again helped her home. At 10.15 she came out again, and this time went to the stick, but still wanted some guidance. At 10.45 she again reached the frame, but immediately came out again, and I once more coaxed her round. After wandering about some time with a larva in her mouth, she dropped down at 11.14. After depositing her larva, she came out directly and went under the larvæ. I again coaxed her round, and this time also she dropped off the glass with her larva. At 12.30 she came out again, and for the last time I helped her round. After this she found her way by herself. At 12.20 another (No. 2) found her way round and returned at 12.37. For the next hour their times were as follows:—

No. 1.	No. 2.
12.46	
	12.47
12.54	12.54
	1. 0
1. 1	
1. 7	
	1. 8
1.12	
	1.14
1.19	
	1.21
1.26	
	1.28
1.32	
	1.34
1.38	
	1.41
1.45	
	1.47
1.52	
	1.54

Thus they both made 9 visits in an hour. As regards actual pace, I found they both did about 6 feet in a minute. Soon after these began, other ants came with them. It was a beautiful day, and all my ants were unusually active. At 1 P.M. I counted 10 on the sticks at once, by 1.30 over 30, and at 5 in the afternoon over 60. They went on working very hard, and forming a continuous stream till I went to bed at 11; and at 4 in the morning I found them still at work; but though they were very anxious and, especially at first, tried very hard to save themselves the trouble of going round, they did not think of jumping down, nor did they throw the larvæ over the edge.

Moreover, as I had placed some sifted mould under the glass, a minute's labour would have been sufficient to heap up one or two particles, and thus make a little mound which would have enabled them to get up and down without going round. A mound $\frac{1}{8}$ inch high would have been sufficient; but it did not occur to them to form one.

The following morning (Oct. 18) I put out some larvæ again at 6 A.M. Some of them soon came; and the same scene continued till 11.30, when I left off observing.

Again, on the 22nd Oct. I placed a few larvæ of *F. flava* in a glass, which I kept continually replenished, which was suspended $\frac{1}{3}$ of an inch above the surface of the frame containing their nest, but only connected with it by tapes 5 feet long. I then, at 6.30, put a *F. nigra* to the larvæ; she took one and tried hard to reach down, but could not do so, and would not jump; so I coaxed her round the tapes. She went into the nest, deposited her larva, and immediately came out again. I put her back on the larvæ at 7.15; she took one, and again tried hard, but ineffectually, to reach down. I therefore again coaxed her round. She went into the nest, deposited her larva, and came out again directly as before. I put her back on the larvæ at 7.35, when the same thing happened again. She got back to the nest at 7.40, and immediately came out again. This time she found her way round the string, with some help from me, and reached the larvæ at 7.50. I helped her home for the last time. The next journey she found her way without assistance, and reached the larvæ at 8.26. After this she returned as follows, viz.:—

At 8.50
9. 0
9.10
9.17
9.28

I now made the length of the journey round the tapes 10 feet. This puzzled her a little at first.

She returned as follows:—

9.41	10.35
9.55	10.44
10. 8	10.55
10.16	11. 6
10.26	11.14 with a friend.

I now made the length 16 feet.

She returned at 11.34
„ 12.14
12·20 two strangers found the larvæ.
„ 12.31
, 12.50
„ 1.10
„ 1.30

She returned at	1.46	
„	1.59	
„	2.10	
„	2.20	
„	2.35	
„	2.45	
„	2.52	
„	3.10	
	3.19	
„	3.29	
„	3.40	
„	3.50	I now put between 700 and 800
„	4.14	larvæ in the glass.
„	4.31	
		4.33 a stranger came.
„	4.44	
„	4.56	
„	5. 8	
		5.12 „
		5.20 „
„	5.25	
„	5.40	
„	6. 6	
		6.10 „
„	6.51	
„	7. 0	
„	7.11	
		7.15 „

It surprised me very much that she preferred to go so far round rather than to face so short a drop.

In illustration of the same curious fact, I several times put specimens of *F. nigra* on slips of glass raised only one third of an inch from the surface of the nest. They remained sometimes three or four hours running about on the glass, and at last seemed to drop off accidentally.

Myrmica ruginodis has the same feeling. One morning, for instance, I placed one in an isolated position, but so that she could escape by dropping one third of an inch. Nevertheless at the same hour on the following morning she was still in captivity, having remained out twenty four hours rather than let herself down this little distance.

In my previous memoir I called attention to M. Forel's interesting statement that when ants quit the pupa stage, they cannot distinguish friends from foes, though three or four days are sufficient to enable them to do so. On this point M. Forel has favoured me with the following interesting explanation :—

"Je prends des fourmis toutes jeunes (blanches encore) de *fourmilières* et *d'espèces* entièrement différentes ; elles se mêlent toutes amicalement les unes aux autres sans distinction, à l'exception d'une *rufibarbis* ☿ qui se trouve être un peu plus âgée et se retire à l'écart avec un cocon ; elle ne se décide à s'allier aux autres que le lendemain. *Dix jours* après le commencement de l'expérience j'établis mes fourmis *qui ont formé une communauté* dans un coin, et je leur apporte de nouvelles jeunes fourmis toutes blanches prises au dehors. Les nouvelles venues elles ne sont pas mal disposées ; elles entrent au contraire dans la fente de mur où sont les autres, mais les anciennes les repoussent, les menacent et les jettent dehors. Cette expérience démontre qu'au bout de dix jours les fourmis distinguent *leurs camarades* des étrangères, tandis qu'elles ne font pas cette distinction dans les premiers jours qui suivent leur éclosion. Si je me suis permis d'écrire qu'il suffit de trois ou quatre jours de vie pour qu'une nouvelle éclose sache reconnaître un ami d'un ennemi, ce n'est pas à la suite d'une expérience directe faite dans le but de fixer ce terme, mais parceque dans les innombrables observations faites sur ces fourmis je me suis assuré qu'il le fallait à peu près ce temps pour atteindre un certain degré de coloration et de consistance, et qu'à ce degré de coloration et de consistance elles commencent à distinguer leurs ennemis, soit qu'elles s'enfuient, soit qu'elles leur montrent les dents. J'aurais du reste peut-être mieux fait de ne pas fixer ainsi ce temps, car il y a tant de variations individuelles, suivant la température &c. que l'on ne peut être assez prudent avant de généraliser. En hiver les jeunes fourmis deviennent beaucoup moins vite adultes qu'en été."

Division of Labour.

In a nest of *F. fusca* which I established in my room on the 13th of December 1874, and in which the females began laying eggs about the middle of April, the pupæ had all come to maturity by the end of August ; and after this very few of the ants came out of the nest. On the 3rd of September I noticed an ant at some

honey which I had put out for their use. From that time to the present (Oct. 30) I have observed no other ant at the honey, while, on the contrary, I have found this particular ant feeding over and over again,—for instance, on the 12th, 13th, 14th, 15th, 17th, 19th, 20th, 24th, 25th, 26th, 27th, and 28th of September, 1st, 5th, 12th, 19th, 22nd, 24th, and 30th of October. As I was away sometimes for two or three days together, and am generally only at home in the mornings and evenings, it is very probable that this ant visited the honey every day, and took in stores to her companions. I have already mentioned a somewhat similar though less marked case.

Concerning Affection and Behaviour to Wounded.

As regards the affection of ants for one another, Latreille makes the following statement:—"Le sens de l'odorat," he says*, "se manifestant d'une manière aussi sensible, je voulois profiter de cette remarque pour en découvrir le siége. On a soupçonné depuis longtemps qu'il résidoit dans les antennes. Je les arrachai à plusieurs fourmis fauves ouvrières, auprès du nid desquelles je me trouvois. Je vis aussitôt ces petits animaux que j'avois ainsi mutilés tomber dans un état d'ivresse ou une espèce de folie. Ils erroient çà et là, et ne reconnoissoient plus leur chemin. Ils m'occupoient; mais je n'étais pas le seul. Quelques autres fourmis s'approchèrent de ces pauvres affligées, portèrent leur langue sur leurs blessures, et y laissèrent tomber une goutte de liqueur. Cet acte de sensibilité se renouvela plusieurs fois; je l'observoi avec une loupe. Animaux compatissans! quelle leçon ne donnez-vous pas aux hommes."

"Jamais," says M. de Saint Fargeau†, "une Fourmi n'en rencontre une de son espèce blessée, sans l'enlever et la transporter à la fourmilière. L'y soigne-t-elle? Je ne sais, mais je vois dans ce fait une bienveillance que je ne retrouve dans aucun autre insecte, même social."

I have not felt disposed to repeat M. Latreille's experiment, nor have I been so fortunate as to witness such a scene accidentally. My limited experiences have been of the opposite character. On one occasion (Aug. 13) a worker of *F. nigra*, belonging to one of my nests, had got severely wounded, but not so much so that she could not feed: for though she had

* Hist. Nat. des Fourmis, p. 41.

† Hist. Nat. des Ins. Hymèn. vol. i. p. 99.

lost five of her tarsi, finding herself near some syrup, she crept to it and began to feed. I laid her gently on her back close to the entrance into the nest. Soon an ant came up to the poor sufferer, crossed antennæ with her for a moment, then went quietly on to the syrup and began to feed. Afterwards three other ants did the same; but none took any more notice of her.

Aug. 15. I found at 1 P.M. a *Myrmica ruginodis* which had lost the terminal portion of both her antennæ. She seemed to have lost her wits. I put her into her nest; but the others took no notice of her; and after wandering about a little, she retired into a solitary place, where she remained from 3 P.M. to 8 without moving. The following morning I looked for her at 5.30, and found her still at the same spot. She remained there till 9, when she came out. She remained out all day; and the following morning I found her dead.

Indeed I have often been surprised that in certain cases ants render one another so little assistance. The tenacity with which they retain their hold on an enemy they have once seized is well known. M. Mocquerys even assures us that the Indians of Brazil made use of this quality in the case of wounds; causing an ant to bite the two lips of the cut and thus bring them together, after which they cut off the ant's head, which thus holds the lips of the wound together. He asserts that he has often seen natives with wounds in course of healing with the assistance of seven or eight ants' heads*! Now I have often observed that some of my ants had the heads of others hanging on to their legs for a considerable time; and as this must certainly be very inconvenient, it seems remarkable that their friends should not relieve them of such an awkward encumbrance.

Recognition of Friends.

I have also made some experiments on the power possessed by ants of recognizing their friends. It will be remembered that Huber gives a most interesting account of the behaviour of some ants, which, after being separated for four months, when brought together again, immediately recognized one another, and "fell to mutual caresses with their antennæ." Forel, on the contrary, regards these movements as indicating fear and surprise rather than affection, though he also is quite inclined to believe, from his

* Ann. Soc. Ent. France, 2 Sér. tom. ii. p. 67.

own observations, that ants would recognize one another after a separation of some months. The observation recorded by Huber was made casually; and he does not seem to have taken any steps to test it by subsequent experiments. The fact is one, however, of so much interest that it seemed to me desirable to make further experiments on the subject. On the 4th of August I separated one of my nest of *F. fusca* into two halves, which I kept entirely apart from one another.

Four days afterwards (August 8th) I put an ant from a different nest into one of these at 8 A.M. She was at once attacked; two hung on to her till about 11, when they left her. Before evening she seemed to have fraternized with them.

Aug. 13. I put another stranger into one of these nests at 9 A.M. At 10.30 one of the ants was dragging her about by an antenna; at 1 she was free; and at 2 I found her among the rest, apparently received as a friend. Two days afterwards she was still well.

Aug. 16. I took one of the ants which I had removed from the others on the 4th and replaced her with her old companions. They seemed to take no notice of her, and certainly did not attack her.

Aug. 20. I put in a stranger at 7.30. At 7.45 one of them had hold of her by the mandibles; at 9.30 one was hanging on to her hind leg; at 10.45 she was free; and I did not see them attack her any more.

Aug. 22. At 7.30 put in a stranger and one of their former companions. One of the ants attacked the former; they took no notice of the latter so far as I could see. At 10.45 they both seemed at home. This stranger I saw repeatedly afterwards, and she had evidently been received completely into the community.

Sept. 3. At 7 A.M. I put a stranger in and also one of their old companions. Neither of them was attacked.

Sept. 17. Put in three strangers; but they were not attacked.

Oct. 3. I put in another stranger; but they did not seem to mind her.

As, therefore, in some cases these ants did not appear disposed to attack strangers, I tried similar experiments with a nest of *Myrmica ruginodis*.

On the 20 August I divided a colony of this species, so that one half were in one nest (No. 9) and the other half in another (No. 15), and kept them entirely apart.

On the 3rd Oct. I put into nest 15 a stranger and an old com-

panion from nest 9. One of them immediately flew at the stranger; of the other they took no notice.

Oct. 18. At 10 A.M. I put in a stranger and a friend from nest 9. In the evening the former was killed, the latter was all right.

Oct 19. I put one in a small bottle with a friend from nest 9. They did not show any enmity. I then put in a stranger; and one of them immediately began to fight with her. In the evening the stranger was dead.

Oct. 24. I again put in a stranger and a friend. The former was attacked, but not the latter. The following day I found the former almost dead, while the friend was all right.

Oct. 31. I again put in a stranger and a friend. The former was at once attacked; but in this case the friend also was, after a bit, seized by the leg, but eventually released again. On the following morning the stranger was dead, the friend was all right.

Nov. 7. Again I put in a stranger and a friend. The latter was soon attacked and eventually killed; of the former they did not seem to me to take any particular notice. I could see no signs of welcome, no gathering round a returned friend; but, on the other hand, she was not attacked.

The Senses.

Much has been written on the use of the antennæ of insects. That they serve as organs of touch all are agreed; but it is almost equally clear that this is not in most cases their only function. Some entomologists regard them as auditory, some as olfactory organs. There is, however, a third alternative, which I would venture to suggest, namely that in those insects in which the sense of hearing is highly developed they may serve as ears, while in those which have a very delicate sense of small, they may act as olfactory organs. This view is not in itself so improbable as might at first sight appear. It is evident that, in the Articulata, organs of sense are developed in various parts of the body. Whether the curious organ discovered by Müller in the metathorax of certain Orthoptera be an ear or not, it must surely be an organ of some sense. Hicks and others have described structures in the halteres and wings of various insects which have all the appearance of being organs of sense; while among the Crustacea we find the remarkable case of *Mysis*, which even has an organ of sense in its tail. It is not then so improbable as might at first sight

appear, that the antennæ should in some species act as ears and in others serve for the perception of odours. The position, moreover, which they occupy renders them a most advantageous situation for an organ of sense. This suggestion would also explain various experiments and observations recorded by skilful entomologists, and which it is otherwise difficult to reconcile with one another.

The Sense of Hearing.

Many eminent observers have regarded the antennæ as auditory organs, and have brought forward strong evidence in favour of their view. Lespés, for instance, found that a female *Locusta viridissima*, which was very sensitive to sound, lost apparently all power of hearing when the antennæ were removed. She lived a fortnight longer and continued to eat. M. Lespés observed no other result except the loss of hearing.

So far as I am aware, no proof has yet been adduced that ants possess the power of hearing. In order, if possible, to throw some light upon this interesting question, I made a variety of loud noises, including those produced by a complete set of tuning-forks, as near as possible to the ants mentioned in the preceding pages, while they were on their journeys to and fro between the nests and the larvæ. In these cases the ants were moving at a steady pace and in a most business-like manner, and any start or alteration of pace would have been at once apparent. I was never able, however, to perceive that they took the slightest notice of any of these sounds. Thinking, however, that they might perhaps be too much absorbed by the idea of the larvæ to take any notice of my interruptions, I took one or two ants at random and put them on a strip of paper, the two ends of which were supported by pins with their bases in water. The ants imprisoned under these circumstances wandered slowly backwards and forwards along the paper. As they did so, I tested them in the same manner as before, but was unable to perceive that they took the slightest notice of any sound which I was able to produce. I then took a large female of *F. ligniperda*, and tethered her on a board to a pin by a delicate thread about 6 inches in length. After wandering about for a while, she stood still, and I then tried her as before; but, like the other ants, she took no notice whatever of the sounds.

It is of course possible, however, if not probable, that ants, even

if deaf to sounds which we hear, may hear others to which we are deaf. On this subject I hope to make some experiments, in which Mr. Spottiswoode has kindly promised to assist me.

The Sense of Smell.

I have also made similar experiments, though with very different results, on the power of smell possessed by ants. I dipped camel's-hair brushes into peppermint-water, essence of cloves, lavender-water, and other strong scents, and suspended them about $\frac{1}{4}$ of an inch above the strips of paper along which the ants were passing in the experiments above recorded. Under these circumstances, while some of the ants passed on without taking any notice, others stopped when they came close to the pencil, and, evidently perceiving the smell, turned back. Soon, however, they returned and passed the scented pencil. After doing this two or three times, they generally took no further notice of the scent. This experiment left no doubt on my mind; still, to make the matter even more clear, I experimented with ants placed on an isolated strip of paper, as described on p. 495. Over the paper, and at such a distance as almost, but not quite, to touch any ant which passed under it, I again suspended a camel's-hair brush, dipped in assafœtida, lavender-water, peppermint-water, essence of cloves, and other scents. In this experiment the results were very marked; and no one who watched the behaviour of the ants under these circumstances could have the slightest doubt as to their power of smell.

I then took a large female of *F. ligniperda* and tethered her on a board by a thread as before. When she was quite quiet I tried her with the tuning-forks; but they did not disturb her in the least. I then approached the feather of a pen very quietly, so as just to touch first one and then the other of the antennæ, which, however, did not move. I then dipped the pen in essence of musk and did the same; the antenna was slowly retracted and drawn quite back. I then repeated the same with the other antenna. If I touched the antenna, the ant started away, apparently smarting. I repeated the same with essence of lavender and with a second ant.

As to Sentiments of Benevolence.

Mr. Grote, in his 'Fragments on Ethical Subjects,' regards it as an evident necessity that no society can exist without the sentiment of morality. "Every one," he says, "who has either spoken or written on the subject has agreed in considering this sentiment as absolutely indispensable to the very existence of society. Without the diffusion of a certain measure of this feeling throughout all the members of the social union, the caprices, the desires, and the passions of each separate individual would render the maintenance of any established communion impossible. Positive morality, under some form or other, has existed in every society of which the world has ever had experience."

If this be so, then ants also must be moral and accountable beings. I cannot, however, of course urge this, because I have elsewhere attempted to show that even as regards man, the case is not by any means clear. In the case of ants, various observers have recorded instances of attachment and affection, some of which have been referred to in my previous papers. With reference to this part of the subject, I have made some further experiments.

Jan. 3, 1876. I immersed an ant (*F. nigra*) in water for half an hour; and when she was then to all appearance drowned, I put her on the strip of paper I mentioned on p. 473. The strip was half an inch wide; and one of my marked ants belonging to the same nest was passing continually to and fro over it. The immersed ant lay there an hour before she recovered herself; and during this time the marked ant passed by 18 times without taking the slightest notice of her.

I then immersed another ant in water for an hour, after which I placed her on the strip of paper as in the preceding case. She was three quarters of an hour before she recovered: during this time two marked ants were passing to and fro; one of them went by 18 times, the other 20 times; and two strangers also went over the paper; but none of them took the slightest notice of their drowned friend.

I then immersed another ant for an hour, and then put her on the strip of paper. She took an hour to recover. The same two marked ants as in the previous observation were at work. One passed 30 times, the other 28 times, besides which five strangers passed by; but not one took the slightest notice.

I immersed three ants for eight hours, and then put them on

the strip of paper. They began to recover in three quarters of an hour, but were not quite themselves till half an hour afterwards. During the first three quarters of an hour two marked ants passed, each four times; and two others also went by. During the following half-hour the two marked ants passed 16 times, and three strangers; but none of them took any notice.

I immersed another ant for forty minutes, and put her on the strip of paper. She recovered in twenty minutes, during which time two strangers passed, and the marked ants, which were the same as in the preceding case, went by 14 times without taking any notice.

I immersed two ants for ten hours, and then placed them on the strip of paper. The same two marked ants passed respectively 18 and 26 times, and one stranger passed again, without taking any notice. After this I left off watching.

I immersed two ants for four hours, and then put them on the strip of paper. They began to recover in an hour, during which two marked ants, not the same as in the preceding case, passed respectively 28 and 10 times, and two others went by; but none of them took any notice.

I immersed an ant for an hour, and then put her on the same strip of paper as in the previous cases. A marked ant passed her twelve times; and three others also took no notice; but, on the other hand, a fourth picked her up and carried her off into the nest.

Again, I immersed an ant for an hour, and put her on the string. The marked ant passed twice, after which she did not return. Soon after, another ant came by and, picking up the immersed one, carried her off to the nest.

I do not bring forward these cases as proof or even as evidence that ants are less tender to friends in distress than previous observers have stated to be the case; but they certainly show that tenderness is not invariably the rule; and, especially when taken in connexion with the two following cases, they are interesting illustrations of the individual differences existing between ants—that there are Priests and Levites, and good Samaritans, among them as among men.

Bees.

Their Appreciation of Colour.

Bees soon accustom themselves to look for honey on papers of particular colours. For instance, on Sept. 13, at 11 A.M., I brought

up a bee from one of my hives; at 11.40 she returned to honey which I had put on a slip of glass on green paper.

She returned at 11.51. And again

„ 12. 1

„ 12.13

„ 12.22

„ 12.33

„ 12.46

„ 12.58

„ 1.12. This time she lost her way in the room.

„ 1.49

„ 2. 1. This time she got stuck in the honey, and had to clean her.

„ 2.25

„ 2.40. I now put red paper instead of the green, and put the green paper with a similar quantity of honey on it a foot off.

„ 2.51 to the honey on green paper. I then gently moved the green paper with the bee on it, back to the old spot. When the bee had gone, I put yellow paper where the green had been, and put the green again a foot off.

„ 3. to the honey on the yellow paper. I disturbed the bee, and she at once flew to the honey on the green paper; when she had gone, I put orange paper in the old place, and put the green paper about a foot off.

„ 3.10 to the honey on the green paper. I again gently moved the paper, with the bee on it, to the usual place; and when the bee had gone, put white paper in the old place, and put the green a foot off.

„ 3.20 to the honey on the green paper. I again gently moved the green paper, with the bee on it, to the old place; and when she had gone, replaced it by blue paper, putting the green a foot off.

„ 3.30 to the honey on the green paper. I again repeated the same thing, putting yellow instead of blue.

She returned at 3.40 to the green paper. I now reversed the position of the yellow and green papers; but

„ 3.51 to the green. After this
„ 4. 6
„ 4.15
„ 4.28, when she left off for the day,

nor were there any bees still working in the garden. The same afternoon a wasp, which I was observing, remained at work till 6.29.

Aug. 20. About noon I brought five bees to some honey at my window. They all soon returned, and numerous friends came with them. One of them I put to some honey on blue paper. She returned as follows, viz. :—

At 12.36	At 2.30
12.42	2.38
12.53	3. 2
1.28	3.10
1.38	3.22
1.49	3.50
2. 2	4. 4
2.11	4.14
2.24	4.23

when I left off watching and shut her out. The longer intervals are due to her having got some honey every now and then on her wings and legs, when she lost a little time in cleaning herself.

Aug. 21. I opened my window at 6 A.M. No bee came till at 7.33 the above one came to the honey on blue paper.

I also placed some honey on orange paper about 2 feet off.

At 7.42 she returned to the honey on blue paper, and again
7.55 she returned to the honey on blue paper.
8. 3 „ „
8.14 „ „
8.25 „ „
8.36 „ „
8.44 „ „
8.54 „ „
9. 5 „ „

I then transposed the papers, but not the honey.

At 9.16	she came back to the honey on blue paper.		I then tranposed the papers again.
9.29	„	„	I then transposed them again.
9.39	„	„	„ „
9.53	„	„	I now put green paper instead of orange, and transposed the places.
10. 0	„	green paper.	I transposed them again.
10. 8	„	blue	„ „
10.21	„	green	I now put red paper instead of green, and transposed the places.
10.30	„	blue	I transposed them again.
10.42	„	„	„ „
10.53	„	„	„ „
11. 4	„	„	„ „
11.16	„	„	I now put white paper instead of red, and transposed the places.
11.28	„	„	I transposed them again.
11.41	„	„	„ „
11.56	„	„	„ „
12. 8	„	„	„ „
12.17	„	„	I now put green paper again instead of white, and transposed the places.
12.27	„	„	I transposed them again.
12.40	„	„	„ „
12.50	„	„	„ „
1. 0	„	„	„ „
1.13	„	„	„ „
1.25	„	„ and then to the green.	„ „
1.40	„	„	„ „
1.47	„	green.	
1.57	„	blue, and then to green.	„ „
2. 6	„	blue.	„ „
2.17	„	„	

The following day I accustomed this bee to green paper. She

made 63 visits (beginning at 7.47 and ending at 6.44), of which 50 were to honey on green paper.

The following day, Aug. 23, she began work:—

At 7.12	returning to honey on green paper.	I then put some on yellow paper about a foot off.
7.19	she turned to the honey on green paper.	I transposed the colours.
7.25	„ „	I replaced the yellow paper by orange and transposed the places.
7.36	„ „	I transposed the colours so that the orange might be on the spot to which the bee was most accustomed.
7.44	„ „	I now put white instead of orange.
7.55	„ „	Transposed the papers.
8. 1	„ „	I now put blue paper instead of white.
8.12	„ blue paper.	I now put red instead of blue.
8.23	„ green paper.	
8.25	„ „	
8.47	„ „	

I then ceased observing and removed the honey.

Thus the bee which was accustomed to green returned to that colour when it was removed about a foot, and replaced by yellow, orange, white, and red; but on the other hand, when blue was so placed, she returned to the blue. I kept this bee under observation till the 28th, but not with reference to colours.

Aug. 24. At 7.45 I put a bee (No. 5) to honey on green paper, to which she kept on returning till 9.44. The next day (Aug. 25) she came at 7.38, and I let her come to the green paper till 9. The following morning she returned at 6 A.M., coming back as follows, viz.:—

At 6.10
6.18
6.25
6.35
6.45

6.54
7. 3
7.13

I now put orange in place of green, and put the green a foot off.

At 7.24	she returned	to	the green.	I replaced the paper with the bee on it; and when she had gone I put light blue in place of the green, and again moved the green a foot off.
7.36	„	„	blue.	I again replaced the paper with the bee on it; and when she had gone I put yellow in place of the green, and again moved the green a foot off.
7.44	„	„	green.	I then did exactly the same, only putting vermilion in place of the green.
7.55	„	„	„	I then did exactly the same, only putting white in place of green.
8. 3	„	„	„	

It would almost seem, from these observations, as if there was less distinction in the eye of the bee between green and blue than between green and other colours. If this should be confirmed, it would have an interesting bearing on the colours of flowers.

April 4. A fine day, but cold. I brought a bee to some honey at my window. She returned at the following times:—

1. 1	2.18
1.17	3.11
1.24	3.20
1.41	3.31
1.50	3.38
2. 1	3.50
2. 6	

But during this time only one other bee came to the honey; and, indeed, after 2 no other bees were at work.

I had on Aug. 20 introduced some bees to honey in my room, since which it had been much visited by them. On the 24th I

put a bee to some honey inside a flower-pot 5 inches high and 5 wide at the base. The flower-pot was laid on its side, and the mouth closed, so that the bee had to come out through the hole in the bottom, which was about $\frac{1}{2}$ an inch in diameter. To make things easier for her, I made her a small alighting-board of wood, the top of which was level with the hole. I then placed the flower-pot on the spot where she was accustomed to find the honey. She had made her first visit that morning at 6.45, returning

at 6.55
7. 5
7.14
7.23 And when I put her, while feeding, into the flower-pot, she found her way out without difficulty.

At 7.40 she returned, but did not seem able to find her way; so I put her in. The same thing happened again at

7.50
8. 6

and 8.20

but at 8.38 she found her way in easily, and had no further difficulty. She returned at

8.53
9. 5
9.14
9.25
9.41
9.55
10. 6 This time a friend came with her and followed her in. I captured her. No. 2 took no notice, but returned

At 10.19	At 12. 9
10.30	12.25
10.44	12.37
10.54	12.50
11. 6	1. 2
11.20	1.14
11.31	1.25
11.44	1.36
11.55	1.47

At 1.57	At 4.44
2. 9	4.55
2.19	5.10
2.31	5.24
2.43	5.35
2.59	5.46
3.23	5.58
3.33	6. 9
3.44	6.20
3.56	6.42
4. 7	7. 0
4.21	7.15
4.34	making 59 visits.

After which she came no more that day. With the one exception above mentioned, during the whole time no other bee came to the honey. I might also mention that I had put out six similar flower-pots in a row, and that this seemed to puzzle the bee a good deal; she frequently buzzed about before them, and flew from one to the other before entering. When she went in, she generally stood still just inside the entrance for about thirty seconds, buzzing loudly with her wings. I thought at first whether this could be intended as a sort of gong to summon other bees to the feast; but, though several were flying about, at any rate none came. The following day (Aug. 25) she came at 6.51, and had made nine journeys up to 8.41, when I left off watching. During this time no other bee came.

Aug. 26. She came at 6.32, and up to 8.43 had made 13 journeys.
27 „ 6. 7 „ 8.43 „ 14 „
28 „ 6.17 „ 7.11 „ 5 „

It was a gloomy morning. No other bee came.

Wasps.

In my previous paper I endeavoured to show that wasps are entitled to at least as much credit as bees for industry. Indeed, as far as my experience goes, they both begin to work earlier in the morning and continue later in the evening. But without making any invidious comparisons, the following cases which I give as showing that wasps do not by any means always bring

friends to share any good things they may have discovered, also prove their great industry. Thus:—

July. I marked a wasp (*V. vulgaris*, ♀) and put her to some honey. All day she kept coming back till past 8 in the evening, but brought no friend. I do not think it necessary to give the times of all her visits; but I may give the times for a few. For instance,

At 3.13 she came to the honey, and at 3.14 returned to her nest.

3.16	„	„	3.18	„
3.20	„	„	3.21	„
3.24	„	„	3.25	„
3.27	„	„	3.28	„
3.29	„	„	3.30	„
3.32	„	„	3.33	„
3.35	„	„	3.36	„
3.40	„	„	3.41	„
3.43	„	„	3.44	„
3.46	„	„	3.47	„
3.49	„	„	3.50	„
3.53	„	„	3.54	„
3.56	„	„	3.57	„
4. 0	„	„	4. 1	„
4. 3	„	„	4. 4	„
4. 6	„	„	4. 7	„
4.10	„	„	4.11	„
4.14				

Thus having made no less than 19 journeys in one hour.

On the 10th of September, 1875, I marked a wasp. On the 11th she came to the honey for the first time,

returning at 7.25, and left at 7.27,

„	7.34	„	7.37
„	7.41	„	7.44
„	7.49	„	7.51
„	7.56	„	7.58
„	8. 3	„	8. 6
„	8.13	„	8.16
„	8.20	„	8.23
„	8.30	„	8.32
„	8.37	„	8.40
„	8.46	„	8.51

She was disturbed.

Returning at	9. 4,	she left at	9. 5
„	9. 9	„	9.10
„	9.15	„	9.16
She was disturbed.			
„	9.30	„	9.32
„	9.50	„	9.54
She was disturbed.			
„	10. 0	„	10. 2
„	10.10	„	10.13
„	10.20	„	10.23
„	10.26	„	10.28
„	10.33	„	10.35
„	10.41	„	10.43
„	10.47	„	10.49
„	10.54	„	10.56
„	11. 0	„	11. 2
„	11. 7	„	11. 9
„	11.14	„	11.16
„	11.20	„	11.22
„	11.26	„	11.29
„	11.33	„	11.35
„	11.39	„	11.41
„	11.45	„	11.47
„	11.53	„	11.54
„	11.59	„	12. 0
„	12. 6	„	12. 8
„	12.14	„	12.16
„	12.20	„	12.22
„	12.28	„	12.30
„	12.35	„	12.37
„	12.42	„	12.44
„	12.49	„	12.52
„	12.55	„	12.57
„	1. 0	„	1. 3
„	1. 8	„	1.10
„	1.14	„	1.15
„	1.19	„	1.21
„	1.25	„	1.27
„	1.31	„	1.33
„	1.37	„	1.39
„	1.43	„	1.45

Returning at	1.51,	she left at	1.53
„	1.58	„	2. 0
„	2. 4	„	2. 6
„	2.11	„	2.13
„	2.19	„	2.20
„	2.28	„	2.30
„	2.33	„	2.35
„	2.40	„	2.42
„	2.45	„	2.47
„	2.53	„	2.56
„	3. 0	„	3. 2
„	3. 4	„	3. 5
„	3. 9	„	3.11
„	3.15	„	3.17
„	3.23	„	3.25
„	3.30	„	3.32
„	3.37	„	3.39
„	3.45	„	3.47
„	3.52	„	3.54
„	4. 0	„	4. 2
„	4. 6	„	4. 9
„	4.15	„	4.17
„	4.22	„	4.24
„	4.29	„	4.31
„	4.35	„	4.37
„	4.41	„	4.43
„	4.50	„	4.52
„	4.57	„	4.59
„	5. 2	„	5. 5
„	5.10	„	5.12
„	5.17	„	5.19
„	5.23	„	5.25
„	5.30	„	5.32
„	5.37	„	5.39
„	5.44	„	5.46
„	5.50	„	5.52
„	5.56	„	5.58
„	6. 2	„	6. 4
„	6. 7	„	6. 9
„	6.13	„	6.15
„	6.20	„	6.22

Returning at 6.28, she left at 6.30
„ 6.34 „ 6.36
„ 6.41 „ 6.43

This was her last visit for the evening, making no less than ninety-four visits in the day, during which time only two other wasps found the honey, though it was lying exposed on a table at an open window. The following morning she came at 6.18 and made twenty visits up to 8.18, after which I did not record them. During this time no stranger came.

No doubt, however, if a wasp is put to honey in an exposed place, other wasps gradually find their way to it. To determine, if possible, whether they were purposely brought, I tried the following experiment. On the 20th of September I marked a wasp and put her to some honey, which she visited assiduously. The following morning I opened my window at 6, and she made her first visit at 6.27, the temperature being 61° Fahr. I then placed the honey in a box communicating with the outside by an india-rubber tube 6 inches long and $\frac{1}{3}$ inch in diameter. The wasp, however, soon got accustomed to it, and went in and out without much loss of time. The 22nd was finer; and when I opened my window at 6 in the morning, she was already waiting outside, the temperature being 61°. The 23rd was rather colder, and she came first at 6.20, the temperature being 61°.

I was not at home during these days; but, as far as I could judge from watching in the mornings and evenings, no other wasp found the honey. On the 24th I had a holiday and timed her as follows. It was rather colder than the preceding days, and she did not come till 6.40, when the temperature was 58°. She returned as follows:—

6.49	8.19
6.58	8.26
7.12	8.35
7.22	8.45
7.32	8.52
7.40	9. 2
7.50	9.12
8. 0	9.45
8. 9	

I had almost closed the window; so that she had a difficulty in finding her way.

9.58	10.32
10.10	10.51

The temperature was still only 60°, and it was raining, scarcely any other wasps about.

11. 1	2.59
11.11	3. 8
11.21	3.14
11.29	3.23
11.40	3.32
11.46	3.40
11.56	3.48
12. 6	3.57
12.14	4.12
12.25	4.20
12.33	4.29
1.21	4.39
1.32	4.47
1.42	4.58
1.53	5. 6
2. 0	5.17
2.11	5.28
2.26	5.35
2.35	5.42
2.51	5.52

This was her last visit. During the whole day no other wasp found the honey. I also tried other wasps, concealing the honey in the same manner, and with a similar result.

I have no doubt some wasps would make even more journeys in a day than those recorded above.

Power of distinguishing Colours.

As regards colours, I satisfied myself that wasps are capable of distinguishing colour, though they do not seem so much guided by it as bees are.

July 25. At 7 A.M. I marked a common worker wasp (*V. vulgaris*) and placed her to some honey on a piece of green paper 7 inches by 4½. She worked with great industry, as recorded on p. 506. After she had got well used to the green paper, I moved it 18 inches off, putting some other honey on blue paper,

where the green had previously been. She returned to the blue. I then replaced the green paper for an hour, after which I moved it 18 inches as before, and put brick-red paper in its place. She returned to the brick-red paper. But although this experiment indicates that this wasp was less strongly affected by colours than the bees which I had previously observed, still I satisfied myself that she was not colour-blind.

I moved the green paper slightly and put the honey, which, as before, was on a slip of plain glass, about 4 feet off. She came back and lit on the green paper, but finding no honey, rose again, and hawked about in search of it. After 90 seconds I put the green paper under the honey, and in 15 seconds she found it. I then, while she was absent at the nest, moved both the honey and the paper about a foot from their previous positions, and placed them about a foot apart. She returned as usual, hovered over the paper, lit on it, rose again, flew about for a few seconds, lit again on the paper, and again rose. After 2 minutes had elapsed, I slipped the paper under the honey, when she almost immediately (within 5 seconds) lit on it. It seems obvious, therefore, that she could see green.

I then tried her with red. I placed the honey on brick-red paper, and left her for an hour, from 5 P.M. to 6, to get accustomed to it. During this time she continued her usual visits. I then put the honey and the coloured paper about a foot apart; she returned first to the paper and then to the honey. I then transposed the honey and the paper. This seemed to puzzle her. She returned to the paper, but did not settle. After she had hawked about for 100 seconds I put the honey on the red paper, when she settled on it at once. I then put the paper and the honey again 18 inches apart. As before, she returned first to the paper, but almost immediately went to the honey. In a similar manner I satisfied myself that she could see yellow.

Again, on August 18th I experimented on two wasps, one of which had been coming more or less regularly to honey on yellow paper for four days, the other for twelve—coming, that is to say, for several days, the whole day long, and on all the others, with two or three exceptions, for about three hours in the day. Both therefore had got well used to the yellow paper. I then put blue paper where the yellow had been, and put the yellow paper with some honey on it about a foot off. Both the wasps returned to the honey on the blue paper. I then moved both the papers

about a foot, but so that the blue was somewhat nearer the original position. Both again returned to the blue. I then transposed the colours, and they both returned to the yellow.

Very similar results were given by the wasp watched on the 11th of September. After she had made twenty visits to honey on blue paper, I put it on yellow paper and moved the blue 12 inches off. She came back to the yellow. I then put vermilion instead of yellow; she came back to the vermilion. I transposed the colours; she came back to the vermilion.

I put white instead of vermilion;				she returned to the blue.	
„ green	„	white	„	„	„
„ orange	„	green	„	„	„
I transposed the colours			„	„	orange.
I put white instead of orange			„	„	white.
„ green	„	white	„	„	blue.
„ purple	„	green	„	„	purple.
„ orange	„	purple	„	„	orange.
„ green	„	orange	„	„	green.
I transposed the colours			„	„	blue.
„	„		„	„	green.

So far therefore she certainly showed no special predilection for the blue. I then left her the rest of the day to visit honey on blue paper exclusively. She made fifty-eight visits to it. The following morning I opened my window at 6.15, when she immediately made her appearance.

I let her make ten more visits to the honey on blue paper, moving it about a foot or so backwards and forwards on the table. I then put orange paper instead of the blue, and put the blue about a foot off. She returned to the orange.

I put yellow instead of orange;				she returned to the yellow.	
„ vermilion	„	yellow	„	„	vermilion.
„ white	„	vermilion	„	„	white.
„ green	„	white	„	„	green.
I transposed the colours;			„	„	blue.
I now put vermilion instead of green, and moved both of them a foot, but so that the vermilion was nearest the window, though touching the blue;			„	„	vermilion.

Again, September 11, I marked a wasp. She returned to the

honey over and over again with her usual assiduity. The following morning I put the honey on green paper; she came backwards and forwards all day. On the 13th I opened my window at 6.8, and she came in immediately. During an hour she made ten journeys. On her leaving the honey for the eleventh time, I placed some honey on vermilion paper where the green had been, and put the honey and the green paper about a foot off.

She returned at

7.25 to the vermilion. I then put orange instead of vermilion.
7.34 „ orange „ blue „ orange.
7.40 „ blue „ white „ blue.
7.47 „ white „ yellow „ white.
7.55 „ yellow and then to the green. I transposed the colours.
8. 2 „ green. I then moved both colours about a foot, but so that the yellow was a little nearer to the old place.

She returned at 8.9 to the yellow.

I then removed the yellow paper and honey, and placed the honey which had been on the green paper about a foot from it on the table.

At 8.15 she returned and lit on the green paper, but immediately flew off to to the honey. I then transposed the honey and the paper.

At 8.24 she returned and again lit on the paper, but immediately flew off to the honey.

Thus, therefore, though it is clear that wasps can distinguish colours, they appear, as might be expected from other considerations, to be less guided by it than is the case with bees.

Direction of Flight.

Every one has heard of a "bee-line." It would be no less correct to talk of a wasp-line. On the 6th of August I marked a wasp, the nest of which was round the corner of the house, so that her direct way home was not out at the window by which she entered, but in the opposite direction, across the room to a window which was closed. I watched her for some hours, during which time she constantly went to the wrong window and lost much time in buzzing about at it. Aug. 7, I was not able to watch her. Aug. 8th and 9th, I watched her from 6.25 A.M., when she made her first visit. She still constantly went to the closed window. Aug. 10th and 11th, I was away from

home. Aug. 12th, she made her first visit at 7.40, and still went to the closed window. Aug. 13th, her first visit was at 6.15; she went to the closed window and remained buzzing about there till 7, when I caught her and put her out at the open one by which she always entered. Aug. 15th and 16th she continued to visit the honey, but still always, even after ten days' experience, continued to go to the closed window, which was in the direct line home; though on finding it closed, she returned and went round through the open window by which she entered.